Polyethylene and Polypropylene

Formolene® Extrusion Blow Molding Process Guide

Formosa Plastics®

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Polyethylene and Polypropylene Extrusion Blow Molding Processing Guide

Polyethylene and Polypropylene are semi-crystalline polymers used extensively due to their unique combination of properties, cost and ease of fabrication. All grades of Formosa Plastics *Formolene*® polyethylene and polypropylene resin consist of both polymer resin and antioxidants. Other additives, like antistats, are added to impart specific functionality. The polymer may be either a pure homopolymer, made by polymerizing ethylene or propylene, or copolymers made from ethylene/propylene and another monomer, like ethylene, hexene, butene or rubber in the case of PP ICP copolymers. Polyethylene and Polypropylene can be processed by a variety of fabrication techniques like film/sheet extrusion, injection molding, blow molding, pipe extrusion and profile extrusion. The following guide refers specially to the blow molding process. There are many variations of blow molding machines, including continuous extrusion, intermittent extrusion, accumulator head and injection blow molding machines. In addition, there are many different machinery manufacturers in each of these categories, with each machine operating slightly differently. Formosa's *Formolene*® polyethylene and polypropylene resin products can be used successfully on all of these machines to blow mold containers of various sizes from very small medicine vials to milk and juice containers to very large tanks.

More information on Formosa Plastics and our *Formolene* ® polyolefin resin products is available at www.fpcusa.com.

INTRODUCTION

The purpose of this guide is to provide insights into the processing of Formosa Plastic's *Formolene*® polyolefin resins. It can also be used as reference tool for troubleshooting and overcoming processing challenges associated with the blow molding process. This guide was developed using a combination of internal and external sources, and is divided into processing and troubleshooting sections.

The processing section addresses safety concerns associated with the blow molding process, helps optimize blow molding machine and resin performance and ensures optimum part quality. Its use, combined with a checklist approach, will prevent and eliminate some of the most common processing problems seen by blow molding machine operators.

The troubleshooting section addresses specific problems associated with the blow molding process and suggests corrective solutions to eliminate them. To facilitate the use of the troubleshooting guide, problems and their suggested solutions have been pre-sorted in one of the following five categories:

I. Parison Formation Problems
II. Part Formation Problems
III. Appearance Problems
IV. Physical Property Deficiencies
V. Other Problems

The troubleshooting table lists the "Problem Observed" and the suggested "Corrective Actions" for each defect. Also, a "Possible Causes" column indicates the possible causes leading to the observed problem. It is believed that this will promote a fundamental understanding of the blow molding process that may be needed to solve problems unique to a particular machine and not covered in conventional troubleshooting guides. However, since blow molding is a complicated process with many critical variables, this guide is not intended to foresee and address all of the processing challenges that might be encountered.

For more indepth processing and troubleshooting assistance, it is recommended that the processor work closely with the equipment manufacturer and Formosa's Technical Service Department.

PROCESSING

I. START UP

A. Safety Equipment

The most important part of operating a blow molding machine is SAFETY. The equipment manufacturer should provide safety rules and requirements pertaining to your specific piece of equipment, including a comprehensive safety checklist. This checklist is usually found in the operating manual of the blow molding machine. Safety rules, requirements, operation conditions and practices set forth by the equipment manufacturer should take precedence over all recommendations in this document.

There are many items that must be inspected prior to running the blow molder. First, make a visual inspection to determine that all safety guards are in place and have not been tampered with or bypassed. Perform a physical check of all safety circuits, safety doors, emergency stops, limit switch safeties and overrides. In most cases, it is recommended that a pre-start checklist be developed to assure that all the safety equipment has been inspected. It is important that the machine and surrounding area is kept clean and free of clutter; housekeeping is often overlooked as a safety item. It is also recommended that a good preventive maintenance program be established, and followed, to keep the equipment in safe and proper working order and all checks are properly documented.

B. Powering up

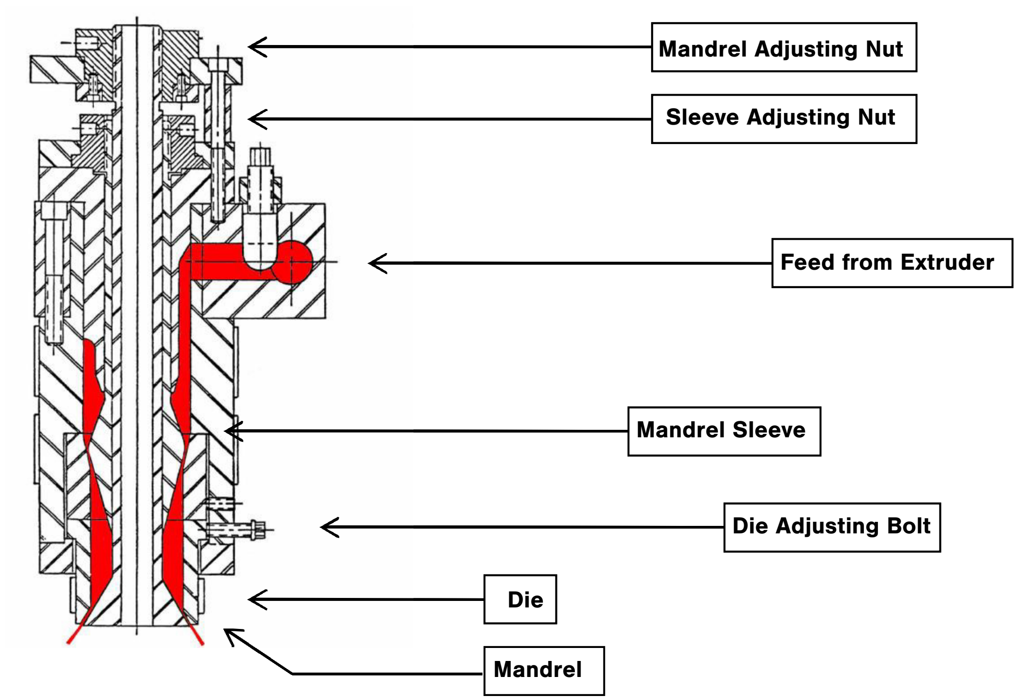
When turning on electrical power to the machine, set the temperature controllers to the operating conditions shown on the machine run sheet. If the machine does not have a run sheet, follow the instructions in the extruder section of this guide. Temperature controllers should be periodically checked for proper performance during both the power up and operation stages. At this point, ensure that the cooling water is on and that it is flowing to the feed throat. NEVER allow the extruder to come up to temperature without cooling to the feed throat. Without cooling, the material at the feed throat could melt and cause an obstruction (bridging). Insure that all zones are coming up to temperature and that no zones are over-riding.

Once the machine has reached its set temperatures, then it should be allowed to come to equilibrium before any material is introduced into the extruder. NEVER start up an extruder until temperatures have reached their set points and the system is allowed to soak until the melt or stock temperature is well above the melting point for the selected material. For example, HDPE has a melting point of 260-280°F; therefore a recommended minimum stock temperature before starting the extruder would be approx. 300-325°F. For PP the recommended minimum stock temperature is 350-360°F. ALWAYS monitor head pressure and motor load when starting up the extruder and do not exceed operating limits determined by the equipment manufacturer. Ensure that the extruder is equipped with a pressure relief device, such as a rupture disk, should maximum extruder pressures ever be exceeded.

C. Head Tooling

Once the temperatures have reached their set points and allowed to sit for a period of time, test the operation of the parison programmer. Increase the die gap and clean the orifice between the die and mandrel using a brass or copper tool. Treat the die lips with special care because any nick or scratch will cause die lines in the molded part. A high temperature silicone release agent can be used to coat the cleaned die lips, land areas and faces to reduce die lip buildup and keep the die lips clean and free of carbon while processing. This should remove any streaking of the parison during processing. Ensure that the use of such a release agent complies with FDA regulations if appropriate for your application. Upon completion, put the mandrel and die back to the original die gap setting.

TYPICAL EXTRUSION BLOW MOLDING HEAD



D. Material Handling Equipment

A complete materials handling operation includes virgin and regrind storage, scrap grinding, blending and material conveyance systems. Virgin material is normally stored in an enclosed area such as a silo, surge bin or storage boxes. The grinder converts scrap parts to granules of suitable size for blending and feeding back to the extruder. The blender mixes the virgin, regrind, color or other additives and post consumer regrind (PCR) in proper proportions, and stores it for delivery to the extruder, on demand. A material conveying system is used to move raw material from virgin and regrind storage areas to the blow molding machine. In addition, machines frequently have a vacuum hopper loader mounted on the extruder hopper to pull the stored material from the blender storage to the extruder.

HDPE/PP plastic granules or pellets are usually available in bulk via railcars or hopper trucks and in semi-bulk containers such as 1,000 lb boxes. No matter how they are delivered, the materials must be carefully handled, as plastic resins are expensive and can burn easily. Plastic resins may easily be contaminated simply by leaving boxes, containers or hoppers open. It is very important to keep all material handling equipment as clean as possible to prevent contamination, as a little bit of contamination can result in hours of down time and lost production. Material should also be inspected before use, if possible, to note color, particle size consistency and any obvious contamination. Storage areas and unloading areas must be kept clean and dry. Materials should be stored away from direct sunlight, sources of heat, and sources of combustion. Strict stock control should be implemented, including lot control and turnover of inventory to reduce the storage time of materials.

E. Air Compressor

The air compressor should be running with a system pressure greater than 80 psig, though check your equipment manufacturer's operating manual. Sufficient blow pressure is required to provide good parison-to-mold contact for optimum part cooling and bottle wall finish.

F. Chiller And Cooling Requirements

Chilling systems are used to provide mold and screw cooling and to control barrel zone and hydraulic oil temperatures. Check the chiller to see that it is operating properly and delivering the fluid temperatures required for your machine. This is also a good time to inspect the coolant delivery pumps for proper operation and pressure. A normal operating range for blow molding is 20 to 60°F. It is to the molder's advantage to use the lowest temperature possible without experiencing condensation in the mold. The mold temperature at which condensation occurs depends upon the relative humidity of the air. As relative humidity increases, the mold temperature must be raised to avoid condensation. Lower mold temperatures will help reduce cycle time and therefore increase overall production speed.

Mold temperature can also have an effect on the physical properties of the molded part. HDPE and PP are semi-crystalline thermoplastic materials and mold temperature will affect the cooling rate of an ejected part. This will change the amount of crystallinity in the finished part which will affect the finished part properties. An increase in the rate of cooling will decrease the amount of crystallinity, which can improve environmental stress crack resistance and decrease part shrinkage and top load strength. Temperature of the cooling medium is not the only consideration in providing efficient heat removal from the part. Reducing melt temperature and increasing blow pressure can also significantly improve part cooling, resulting in lower cycle times. Mold design considerations such as the number of cooling channels, diameter of the cooling channels, and thermal conductivity of the mold material (i.e. aluminum vs. beryllium copper) are also variables that will change the rate of cooling.

II. NORMAL OPERATION

A. Extruder Temperatures

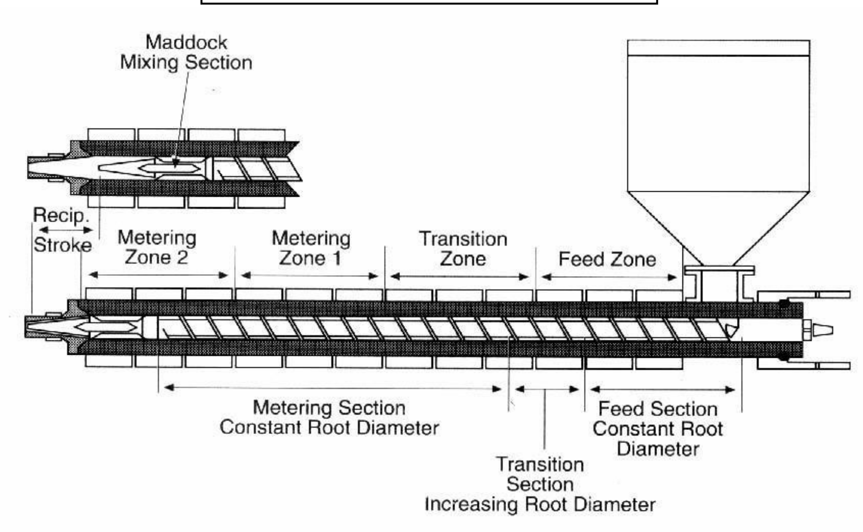
L/D ratio = 24:1 to 36:1
Compression ratio = 3:1 to 4:1
Melt Temperature = PE - 340 - 425 °F (171 - 218°C), PP - 360 – 450 °F (182 - 232°C)
Pellets Drying– Not essential
Regrind ratio– 0 to 70% depending upon the end product, quality of regrind and screw configuration.

Processing temperatures for blow molding polyethylene and polypropylene are not specific. Instead, they vary from machine to machine according to a number of variables including part size, cycle time, number of molds and back pressure on the screw. Processing temperatures will also vary according to the resin properties such as melt index, density, additives, blends, etc. Once the extruder screw is actually turning and delivering melted plastic to the blow molding head, the heat necessary to melt and mix the material comes primarily from shear heating, not the barrel zone heaters. This shear heat energy comes from the friction that occurs when the pellets are rubbed together, compressed against the barrel wall and conveyed forward towards the delivery end of the screw.

Barrel cooling zones can effectively remove heat from the melt while it is extruding, and can reduce temperature "overshoot" from an incorrect temperature profile or a worn screw or barrel. The extruder should be operated to minimize the amount of frictional heat and eliminate "overshooting" on the heating sections. However, the amount of shear heat produced can often cause a temperature “overshoot” even with good barrel zone cooling. This makes a correct temperature profile especially important on machines that do not have a cooling system on the barrel. As a general rule, it is better to remove heat during the actual extrusion process rather than the part cooling process. Try to achieve the lowest melt temperature possible consistent with acceptable parts. Use the following general parameters as a starting point and adjust conditions as appropriate.

Higher extrusion temperatures can reduce back pressure and motor load, reduce or eliminate melt fracture, improve mixing and melt quality, and reduce die swell. However, they will also increase the cycle time required to achieve proper part cooling, decrease melt strength and increase smoke and odor. Melt fracture can sometimes be eliminated or reduced by increasing only the die lip temperature. As a good manufacturing practice, try to achieve the lowest melt temperature possible consistent with acceptable parts.

TYPICAL BLOW MOLDING EXTRUDER



PP- Use a ramped profile starting at 330°F and increase the set points in steps through the extruder feed, compression, metering and head sections to a temperature set point of 370 °F.

HDPE- Use a ramped profile starting at 300°F and increase the set points in steps through the extruder feed, compression, metering and head sections to a temperature set point of 350 °F.

LDPE- Use a ramped profile starting at 300°F and increase the temperature set points in steps through the extruder feed, compression and metering sections to a head temperature of 325 °F.

B. Regrind

Polyolefin resins are typically characterized as being thermally stable. However, antioxidants are usually added to the material to increase their life through several molding and regrind cycles. Therefore you can mold 100% regrind or add regrind to virgin material in any concentration as long as they are similar grades. However, the continued recycling of 100% reground material is not recommended since material degradation will increase as the antioxidant is used up. A slight increase in back pressure may be required if the particle size of the regrind is different from that of the virgin resin. The addition of regrind will also decrease die swell to some extent.

C. Back Pressure

Back pressure improves the mixing of the polymer melt. It can sometimes be increased to eliminate voids and unmelted pellets in the finished part. However, increasing back pressure also tends to lengthen the overall cycle time because it can increase frictional heating and raise the melt temperature. As a good manufacturing practice, use the minimum back pressure necessary to achieve proper mixing.

D. Processing And Cycle Improvement Tips

Here are several useful tips for improving your processing and cycle times:

1. For problem solving and trouble shooting, use the Formosa Troubleshooting Guide and the equipment operating manual.
2. Set the high pressure air no less than 80 psig. If the machine has low pressure air, set it at 10 to 35 psig or refer to the equipment operating manual. High pressure air should be set slightly below system pressure.
3. Set part weights at the low end of the specification to reduce screw rpm and/or cycle time.
4. Minimize extruder back pressure to reduce frictional heat, but be careful not to compromise mixing in the system.
5. Maintain the lowest possible heat profile on the machine to limit the amount of heat that must be removed during the blowing part of the cycle. This helps reduce cycle time.
6. Observe the machine temperature controllers during normal operation. Remember, wires can break, causing heat sensors and temperature controllers to loose their ability to function properly.
7. If your machine has a nitrogen bladder to assist parison extrusion, set the pressure as high as possible to decrease parison drop time. Maximize hydraulic pressure for reciprocating screw and accumulator head machines to decrease parison drop time.
8. Set the mold close limit switch so that the molds will close on a moving parison.
9. Provide auxiliary cooling to parts after they have been removed from the molds. If possible, increase the time between molding and flash removal by adding part conveying time or distance. This can aid in deflashing the part and reduce the cycle time of the machine.
10. Watch the cycle carefully and eliminate dead time where ever possible. Specific items to check include exhaust time and the position where the molds start closing.
11. Machines with shot size control should reach the shot size limit slightly before molds are fully open.
12. Some machines have a head choke system that regulates plastic flow to individual heads. These systems should be open as much as possible to reduce back pressure on the system.
13. Review your resin specifications to match necessary physical properties of the product being produced. Matching the proper resin with the part being produced may reduce your cycle time.

*Remember that the cooler the extrudate, the less heat the molds will have to remove. This usually reduces cycle time.

III. SHUTDOWN

It is important to adopt good shutdown procedures to save time and money. Proper shutdown procedures will prevent excessive degradation of material in the extruder and die and will reduce purging and machine clean out time. During periods of temporary production down time, it may be useful to periodically extrude the plastic through the system to prevent degradation and reduce the time the material is exposed to high temperatures. For longer shutdowns, such as over nights and weekends, lower the barrel and head set points and run the extruder at low rates for a short time to reduce the overall temperature of the system. Finally, shut off power to the system and support equipment and clean up the area. Generally, materials such as HDPE, LDPE and PP are not considered heat sensitive and can remain in the extruder with little or no effect.

Reducing the amount of heat to which the material is exposed will prevent material degradation during shutdown. If material degradation is a problem during shutdown, then a secondary antioxidant masterbatch can be added to the blow molding system prior to shut down.

FORMOSA PLASTICS TROUBLESHOOTING GUIDE

Common Blow Molding Problems and Possible Corrective Actions

Problem Observed	Possible Causes	Possible Corrective Actions
I. Parison Formation Problems		
Parison Hooking (not dropping straight)	1. Non-uniform parison walls. 2. Dirty die/mandrel channel. 3. Head temperature not uniform. 4. Loose mandrel or die pin. 5. Air blowing on parison. 6. Static charge on parison. 7. Warped die or mandrel.	1. Center die adjusting ring around mandrel to correct. 2. Clean channel. 3a. Replace defective head/die heaters. 3b. Stagger heat band gaps on head; Check for ambient air blowing on head. 4. Tighten die pin. 5. Shield parisons from moving air. 6. Employ method of neutralizing charge. Install deionizing air or static bar. 7. Replace damaged component.
Parison Curtaining, Folding or Webbing	1. High melt temperature. 2. Parison wall too thin at top. 3. Material mismatch.	1. Correct high melt temperatures. Check for run away heat zones and insure extruder cooling devices are working properly. 2a. Reprogram to increase die gap at top of parison. 2b. Adjust pre-blow air. 3a. Match material swell characteristics to application needs. 3b. If the swell is too high, raise the melt temperature, reduce parison extrusion rate, decrease pre-blow air or reduce the size of the die and mandrel. 3c. If the swell is too low, lowering the melt temperature, increasing parison extrusion rate, increasing pre-blow air or increasing the size of the die and mandrel may solve the problem.
Parison Curl and Doughnut Formation	1. Cold mandrel or die. 2. Foreign matter or degraded material in the die bushing. 3. Damaged tooling. 4. Vertical misalignment of die or mandrel.	1a. Permit sufficient warm up time before attempting production. 1b. Insure that die bushing heater is operative, if so equipped. 2. Clean die. 3. Check tooling for damage. 4. Check positioning of the die and mandrel. The die bushing may need to be machined so that it extends below the die face.
Parison Stringing	1. Melt temperature too high. 2. High back or fill pressure.	1. Gradually lower the melt temperature. 2. Reduce back or fill pressure until weeping stops.

Problem Observed	Possible Causes	Possible Corrective Actions
Parison Sag	1. High melt temperature. 2. Material melt index too high; melt strength too low. 3. Extrusion rate too slow (parison drop time too long). 4. Parison weight too heavy. 5. Mold closing too slowly.	1. Decrease melt temperature. 2. Use lower melt index material. 3a. Increase extrusion rate. 3b. Decrease parison drop/hang time. 4a. Reduce tail length. 4b. Reprogram to reduce weight in tail. 5a. Increase speed of mold close. 5b. Lubricate tie bar bushing. 5c. Adjust pre-blow or support air.
Poor Blow Pin Penetration	1. Needle is blunt. 2. Melt temperature too high.	1. Sharpen needle or increase penetration speed. 2a. Reduce melt temperature. 2b. Reduce parison thickness at penetration point.
Smoking	1. Melt temperature too high. 2. Contamination in material. 3. Heat controller malfunction.	1. Decrease melt temperature. 2. Check for contamination. 3. Check heat controllers.

Back to top

II. Part Formation Problems		
Lost or Webbed Handles	1. Misaligned molds. 2. Parison hooking. 3. Parison melt stringing. 4. Low flare or diameter swell.	1. Realign molds to catch handles. 2. Realign die adjusting ring. 3. Reduce melt temperature. 4a. Lower melt temperature. 4b. Reduce parison drop time. 4c. Use larger die for part.
Part Weld and Pinchoff Problems	1. Maladjusted trimming equipment. 2. High melt/mold temperature.	1. Adjust trimming equipment. 2a. Lower the melt temperature in 5-10 °F Increments until the cutting stops. 2b. Reduce mold temperature.
	3. Low melt temperature.	3. Raise melt temperature in 5-10°F increments until the cutting stops.
	4. Mold closing too rapidly.	4. Reduce mold closing speed.
	5. Improper amount of material in pinch.	5a. Decrease clamp pause to thin the pinch. Increase the clamp pause to thicken the pinch. 5b. Adjust programming to increase material in pinch off area.
	6. Pinch-off lands too wide.	6. Decrease width of pinch-off land.
	7. Flash pockets too deep.	7a. Reduce depth of flash pockets. 7b. Adjust programming to thicken bottom pinch.
Hole/Slit in Parting Line, Thin Parting Line	1. Mold not fully closed.	1a. Clean mold faces. 1b. Tighten mold lockup. 1c. Increase mold closing pressure. 1d. Check mold parting line for poor match. 1e. Set downward travel of blow pins. 1f. Decrease blow air pressure.
	2. Vents plugged or restricted.	2. Clean and/or repair vents.

Problem Observed	Possible Causes	Possible Corrective Actions
Part Does Not Blow or Incomplete Blowing	1. Parison too short 2. Improper mold closing speed. 3. Blow pressure too high, parison inflation rate too rapid. 4. Blow-up ratio too high. 5. Blow air restricted. 6. Material swell too low. 7. Moisture or entrapped air. 8. Contamination or fines. 9. Clamp pressure too low.	1a. Increase shot size or extruder rpm. 1b. Close mold before full snapback of parison occurs. 2. Adjust mold closing speed. 3. Reduce blow pressure and/or inflation rate. 4. Check head tooling. A larger die diameter may be needed. 5. Check blow air and exhaust system for leakage. 6a. Lower the melt temperature. 6b. Use higher swell material. 7a. Eliminate air or moisture in the material as explained in the "Bubbles" section. 7b. Let the extruder run for a few minutes. The problem could be caused by letting the hopper run out of material before refilling. See "Bubbles" for other possible causes. 8. Check for sources of contamination or fines. 9. Check clamp pressure.
Excessive Flash	1. Parison diameter too large. 2. Flash pockets too shallow. 3. Improper mold closure.	1a. Reduce pre-blow air. 1b. Reduce parison extrusion rate. 1c. Check material selection, a lower swell material may be needed. 1d. Reduce tooling diameter. 2. Consult mold maker. 3a. Check for obstruction. 3b. Increase locking and check for mold mismatch.
Top Flash Not Separating from Neck Finish	1. Damaged shear ring, blow pin or cutting ring. 2. Insufficient shear force on neck.	1a. Replace shear ring or blow pin. 1b. Sharpen or replace cutting ring. 2a. Adjust down position of blow pin for pull-up systems. 2b. Increase downward force of low pin for ram-down systems.
Tail Flash Not Separating from Part	1. Parison too short. 2. Flash pocket too deep.	1. Lengthen parison. 2. Contact mold maker.
Parts Sticking in Mold	1. Mold temperature too high. 2. Parison hooking. 3. Swing arm out of adjustment. 4. Molds not opening far enough. 5. Tail too short. 6. Insufficient exhaust time.	1a. Improve mold cooling and heat transfer and slightly reduce mold temperature. 1b. Increase cooling time. 2. Adjust parison drop. 3. Adjust swing arms. 4. Adjust mold open stop position. 5a. Increase screw rpm. 5b. Increase blow or cycle time. 6. Increase exhaust time.
Part Too Hot	1. Melt temperature too high. 2. Mold temperature too high. 3. Cycle time too short. 4. Clogged coolant lines/channels.	1a. Check heater bands. 1b. Reduce back pressure. 2. Decrease mold temperature. 3. Increase blow time to extend cycle time. 4. Clean lines/channels.

Back to top

Problem Observed	Possible Causes	Possible Corrective Actions
III. Appearance Problems		
Die Lines or Streaking in Parison	1. Foreign matter lodged between the die and mandrel. 2. Contaminated material. 3. Carbon or degraded material in head. 4. Burned-out heater band. 5. Melt overheating. 6. Damaged tooling.	1. Increase die gap briefly to purge foreign matter, then reset to original gap. 2. Check for dirt, dust, and lint in unprocessed material and regrind. 3a. Clean die and mandrel with a copper or brass tool. 3b. Extrude a continuous parison and blow a container with a thin wall. If the container has heavy streaks, a complete head cleaning may be in order. 4. Replace non-functioning band. 5. Check for overriding temperature in the barrel and head and correct. 6. Repair or replace tooling as needed.
Poor Part Surface (Roughness, Pits, Orange Peel, Etc.)	1. Dirty die/head tooling. 2. Poor melt surface due melt fractue. 3. Poor mold surface. 4. Inadequate vents which preclude rapid escape of air. 5. Low blow pressure or inflation rate. 6. Air leak around blow pin. 7. Condensed water in the mold.	1. Clean tooling. 2a Adjust die gap. Open the gap on shuttle machines, close the gap on reciprocating machines. 2b. Adjust parison extrusion rate. Lower the rate on shuttle machines, increase the rate on reciprocating units. 2c. Increase melt temperature or change to a higher melt index material. 3. Check finish of mold surface. 4. Check vents along mold parting line; minor reworking may be necessary. 5a. Check air system for leaks and proper pressure during blowing. 5b. Adjust timing of low pressure/high pressure blow. 5c. Insure that the blow pin is large enough to handle the required amount of air to fully and rapidly blow the part. 5d. Check for restrictions or partial plugging of air lines. 6. Check for leakage around blow pin. 7a. Check for low mold temperature in combination with environmental humidity. 7b. If mold temperature cannot be raised, investigate plant or machine humidity control.
	8. Melt temperature too low.	8. Gradually increase the melt temperature but avoid overly high melt temperature since other problems may result.
	9. Uneven die temperature.	9a. Check for source of air that may be cooling the die-leaking blow air, fans, and drafts. 9b. Insure that die heaters are functioning properly.
Poor Definition of Detail	1. Blow air pressure too low. 2. Poor mold venting.	1a. Check air system for leaks and proper pressure during blowing. 1b. Adjust timing of low pressure/high pressure blow. 2a. Clean mold vents. 2b. Consult mold maker.

Problem Observed	Possible Causes	Possible Corrective Actions
Bubbles	1. Insufficient back pressure. 2. Worn extruder screw or barrel.	1a. Reciprocating unit –increase back pressure. 1b. Continuous extrusion unit-change screen pack to finer mesh. 2. Reduce screw speed to allow additional residence time in the screw.
Unmelted Material, Cold Spots or Marbleizing	1. Insufficient back pressure. 2. Contamination or fines. 3. Mixture of material having a lower melt index. 4. Melt too cold. 5. Cycle too fast. 6. Worn screw or barrel.	1a. Reciprocating unit-adjust back pressure gauge. 1b. Continuous extrusion unit-change screen pack to finer mesh. 2. Check for sources of contamination or fines. 3. Avoid improper material mixing. 4. Increase melt temperature. 5. Increase cycle time. 6. Check screw and barrel for wear. Periodically perform throughput studies to assess condition of screw and barrel.
Horizontal Rings	1. Programming changes too drastic.	1a. Decrease the magnitude of weight change between programming steps. 1b. Insure that that mandrel does not have an obstruction preventing smooth programming movement. 1c. Meter oil flow to programming cylinder.

Back to top

IV. Physical Property Deficiencies		
Low Environmental Stress Crack Resistance (ESCR)	1. Bottle pinch not centered in mold. 2. Improper part design. 3. Incorrect material for application. 4. Melt temperature too low. 5. Melt temperature too high. 6. Mismatched molds. 7. Worn or damaged trimmer nests. 8. Color concentrate. 9. Excessive regrind.	1a. Center parison in bottom pinch (correct hooking parison). 1b. Reduce die diameter. 1c. Reduce diameter swell by increasing melt temperature or reduce tooling size. 2. Check part design. 3. Use proper material. 4. Increase melt temperature. 5. Decrease melt temperature. 6. Realign molds. 7. Repair or replace trimmer nests. 8. Check color loading. 9. Reduce regrind rate.
Low Impact Strength	1. Poor wall distribution. 2. Thin parting line. 3. Weak pinch weld. 4. Insufficient wall thickness at edge of in mold label (IML). 5. Mismatched molds. 6. Worn or damaged trimmer nest. 7. Poor mold venting. 8. Excessive regrind.	1. Increase wall thickness at failure point. 2. See "Hole/Slit in Parting Line, Thin Parting Line" for remedies. 3. See "Part Weld or Pinch-Off Problems" for remedies. 4. Examine part design.. 5. Realign molds. 6. Replace trimmer nest. 7. Clean vents. 8. Reduce regrind rate.

Problem Observed	Possible Causes	Possible Corrective Actions
Low TopLoad Strength	1. Uneven wall distribution. 2. Low part weight. 3. Poor part design. 4. Incorrect material for application.	1a. Reprogram parison. 1b. Reduce parison sag. 2. Increase part weight. 3a. Redesign container to distribute top load across a wider area. 3b. Avoid sharp corners and sharp radius bends. 4. Use proper material.

Back to top

V. Other Problems		
Non-uniform Wall Section Around Circumference	1. Inaccurate die centering. 2. Head temperature not uniform.	1. Center die to provide uniform distribution of wall section. 2a. Stagger heater band gaps on head. 2b. Shield heads from air currents or outside temperature effects.
Wall Section Too Thin at Top of Part	1. Excessive draw down of the parison due to slow extrusion rate. 2. Excessive draw down due to high melt temperature. 3. Parison expansion too late.	1a. Increase extrusion rate. 1b. Reprogram to increase wall thickness at top of part. 2. Decrease melt temperature. 3. Close mold sooner and expand more rapidly.
Excessive Shrinkage	1. Blown part ejected when too hot. 2. Inadequate mold cooling.	1a. Reduce mold temperature. 1b. Reduce melt temperature. 1c. Increase blow time. 1d. Check blow pressure. 2. Clean mold cooling channels.
Part Volume Too High	1. Part weight too low. 2. Bottle ejected too cold. 3. Wrong mold volume. 4. Volume-reducing inserts not used. 5. Blow air pressure too high. 6. Part storage areas too cold.	1. Increase part weight. 2a. Increase mold temperature. 2b. Reduce cycle time. 3. Resize mold. 4. Install inserts. 5. Reduce blow air pressure. 6. Increase storage area temperature or warehousing time.
Part Volume Too Low	1. Part weight too high. 2. Bottle ejected too hot. 3. Mold volume incorrect. 4. Volume-reducing inserts used. . 5. Blow air pressure too low. 6. Part storage areas too hot. 7. Melt temperature too high.	1. Reduce part weight. 2a. Reduce mold temperature. 2b. Increase cycle time. 3. Resize mold. 4. Use volume inserts that are correctly sized for part shrinkage. 5. Check air system for leaks and proper pressure during blowing. 6. Reduce storage area temperature or warehousing time. 7. Lower melt temperature.

Problem Observed	Possible Causes	Possible Corrective Actions
Warpage (Rocker Bottoms and Oval Necks)	1. Insufficient mold cooling. 2. Melt temperature too high. 3. Blocked cooling channels. 4. Cycle time too short. 5. Molds open before fully exhausted. 6. Poorly designed part.	1a. Determine whether increased water flowwill stop warpage. 1b. Reduce mold temperature. 1c. Increase cycle time to provide longer cooling. 2. Reduce mold temperature. 3. Increase cycle time to provide longer cooling. 4. Adjust cycle time as needed. 5. Increase exhaust time. 6. Check material distribution in the part for unnecessarily thick or thin sections.
Cap Leakage	1. Worn or damaged blow pin or shear steel; wrong blow pin and shear steel dimensions. 2. Blow pin alignment. 3. Mold alignment (mismatch). 4. Wrong neck insert dimensions. 5. Wrong cap dimensions. 6. Pleating (vertical web inside neck). 7. Neck hitting position bar on cooling bed. 8. Air leakage during blowing.	1. Replace blow pin and/or shear steel. 2. Align blow pin. 3. Replace guide pins and bushings. 4. Check insert dimensions versus part drawing. 5. Check and insure that proper caps are being used. 6. Adjust pre-blow air system. Blow low pressure air before mold closes and/or increase preblow air pressure. 7. Adjust swing arm finger opening. 8. Identify source of leak and repair.

Back to top

Revised April 2025

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